CEMENT AND LIME MANUFACTURE

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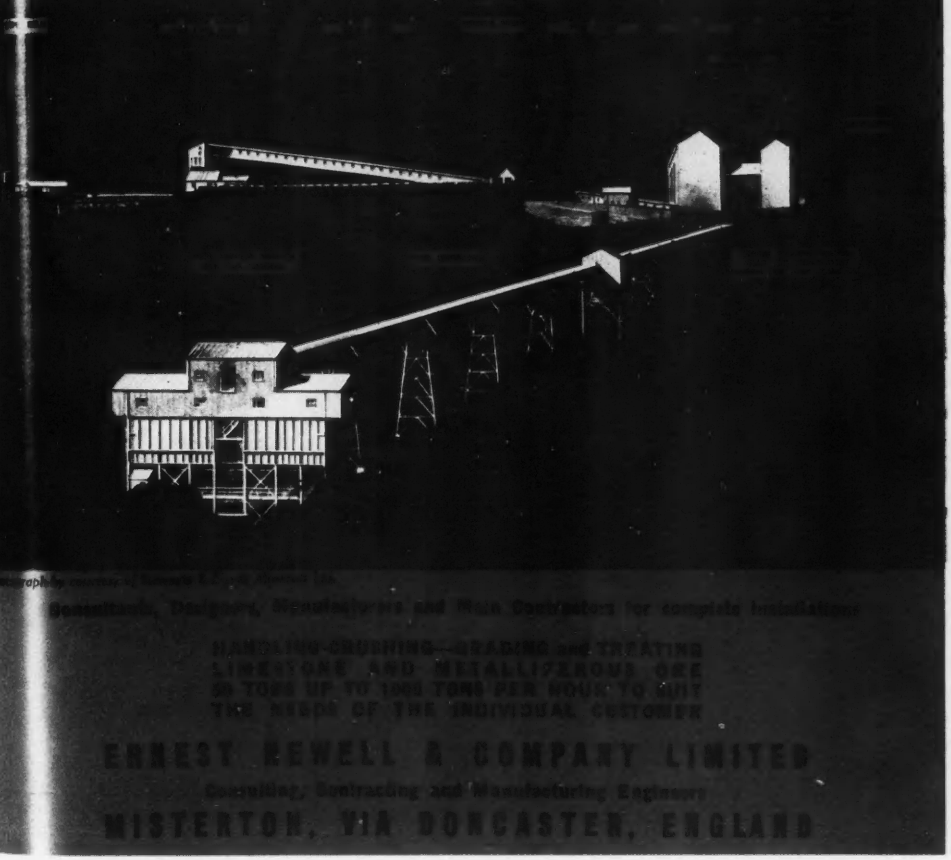

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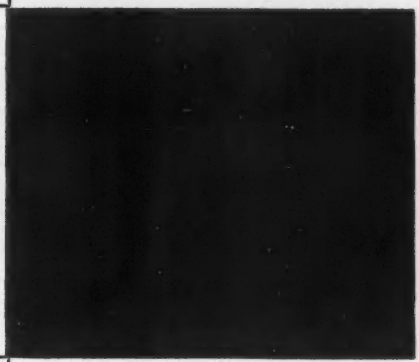

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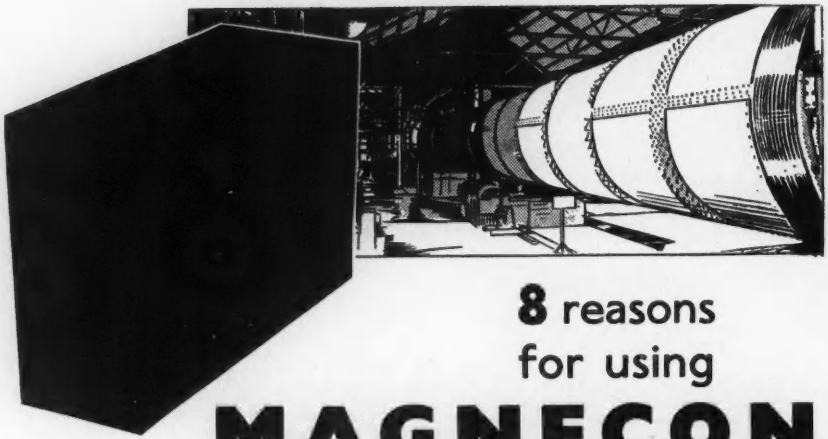

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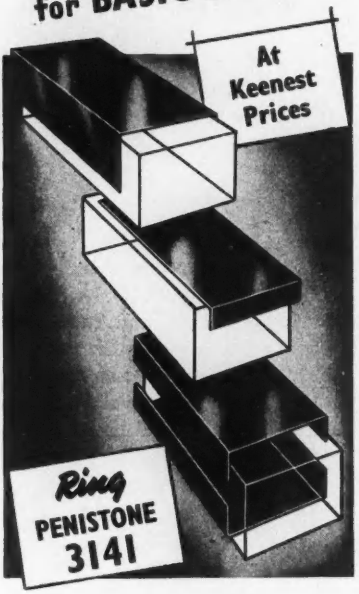

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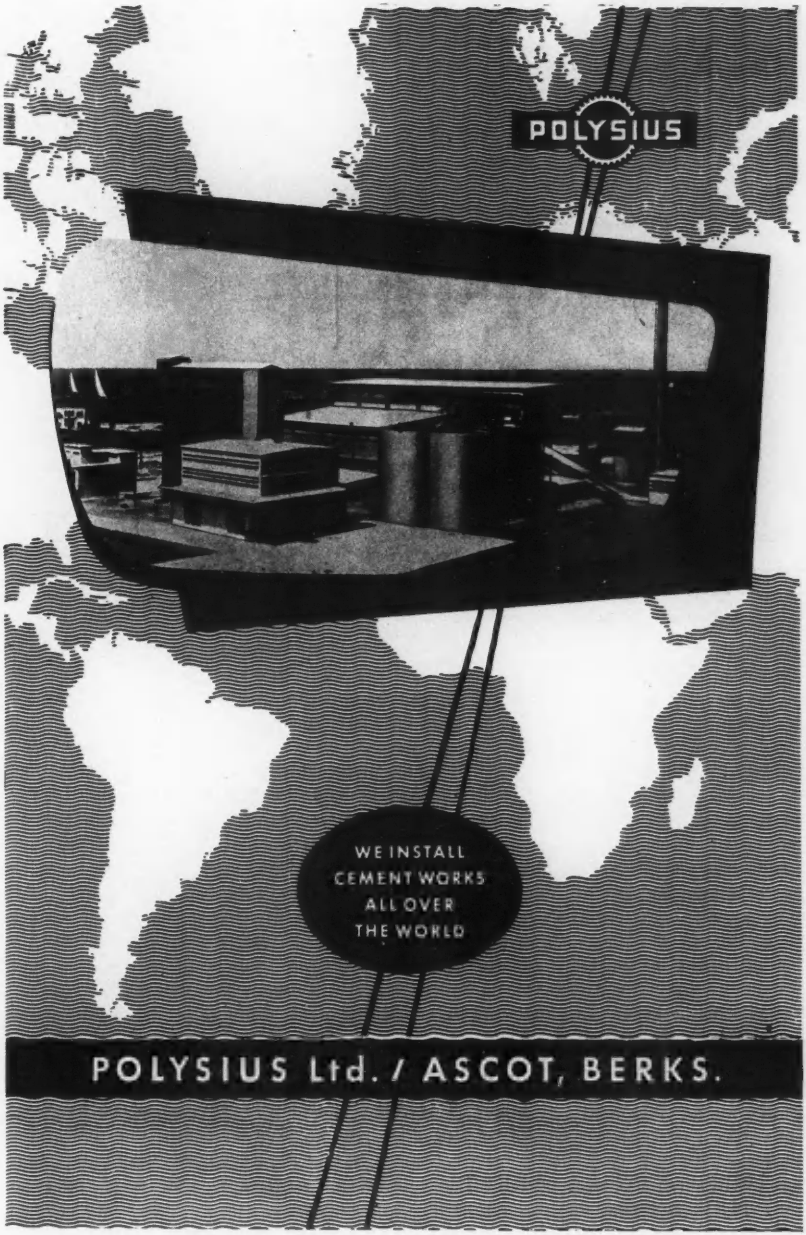
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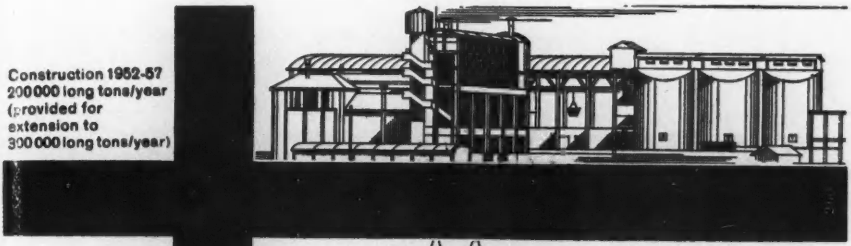
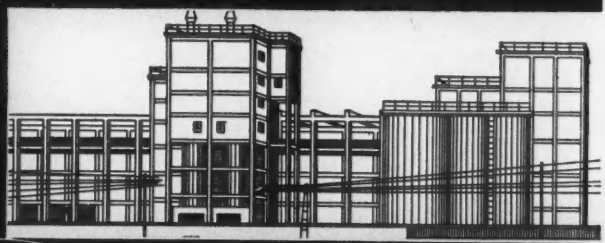


Construction 1952-57
200000 long tons/year
(provided for
extension to
300000 long tons/year)



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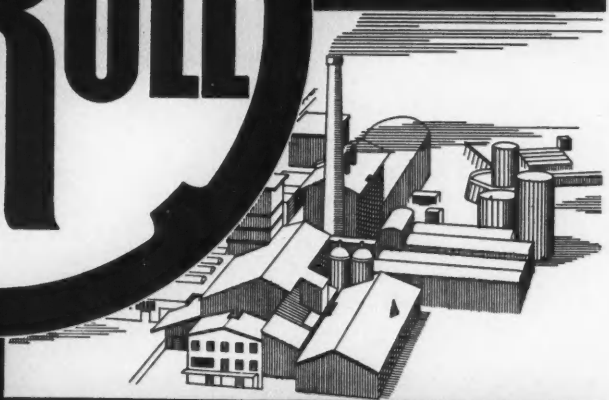

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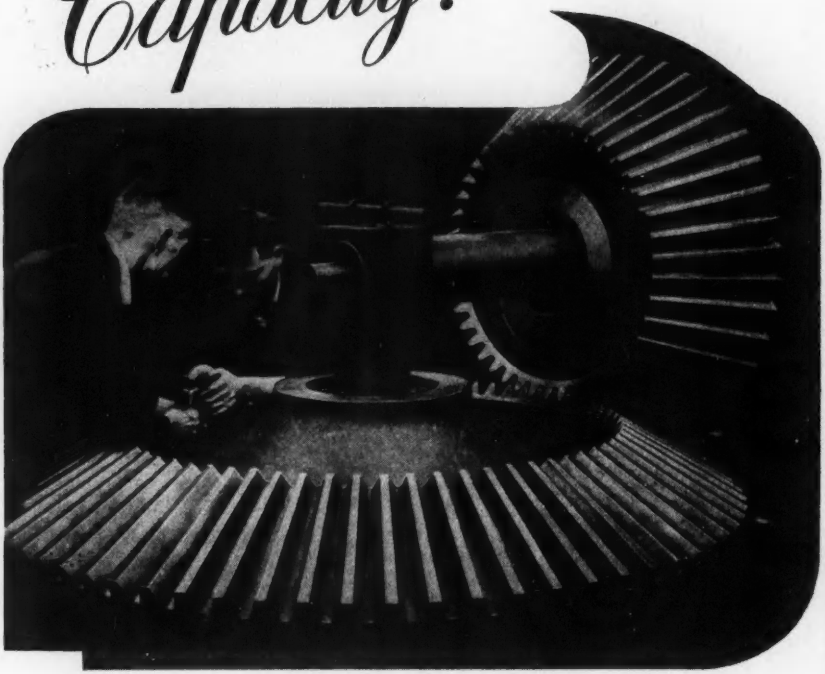

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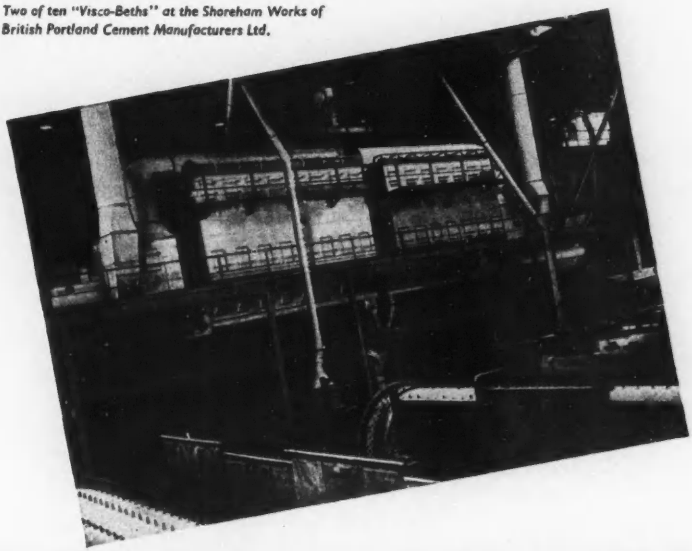

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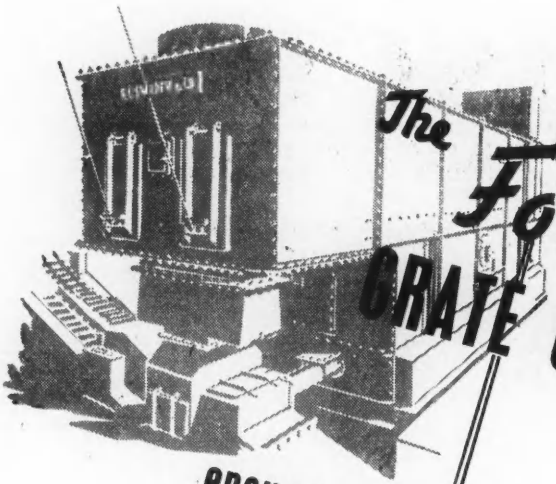

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VOLUME XXXI. NUMBER 3. MAY, 1958

New British Standards for Portland Cement.

RECENTLY the British Standards Institution issued revisions of B.S. No. 12 for Ordinary and Rapid-hardening Portland Cements, B.S. No. 146 for Portland-blastfurnace Cement, and B.S. No. 1370 for Low-heat Portland Cement.

It is eleven years since B.S. No. 12 was last revised. The principal innovation is the introduction of a new test in which the quality of cement is measured by compressive tests on 4 in. concrete cubes. This test replaces the tensile test on mortar briquettes which was introduced in the first standard for cement issued in this country in 1904. The assessment of the quality of cement by tests of the material in which it is most commonly used is logical, and its introduction has been delayed due to the difficulties of standardising such a test so that the results would be a criterion of the quality of the cement alone and would not be affected by the aggregate. Some years of research and development, and extensive co-operative testing in this country, in the Commonwealth, and in Europe have, however, resulted in a method that is considered to be satisfactory. The new B.S. No. 12 is the first standard in the world to include such a test.

The new test is based on the fact that the strength of concrete having a fixed water-cement ratio and a fixed consistency as measured by the slump test is independent of the aggregate provided that this has adequately high strength and low absorption. The aggregates that may be used are flint, granite, limestone, porphyry, and quartzite complying with the requirements of British Standard No. 882, "Concrete Aggregates from Natural Sources," all of which give similar results in tests made in accordance with B.S. No. 12. The test therefore avoids the need for a standard aggregate, and suitable materials are available in most countries. The test as described in the Standard appears to be tedious, but it has been found that after a few attempts it presents no difficulty to experienced testers. Each cube is made separately, using fixed weights of cement and water and such a quantity of aggregate as will, with the cement and water, exactly

fill the mould after standard hand compaction. The total volume of materials is kept constant, and the proportioning of the sand and stone is arranged to produce the required consistency. The result is an aggregate-cement ratio of about 6 : 1 by weight, a water-cement ratio of exactly 0·60, and a slump of ½ in. to 2 in. The compressive strength is an indication of the quality of the cement alone. The minimum strengths required are 1200 lb. per square inch at three days and 2000 lb. per square inch at seven days in the case of ordinary Portland cement, and 1700 lb. per square inch at three days and 2500 lb. per square inch at seven days in the case of rapid-hardening Portland cement.

The concrete test appears in the Standard as an alternative to the familiar vibrated-mortar cube test; either of these may be used. If, therefore, there should be difficulty in agreeing on an aggregate for the concrete test the vibrated-mortar test can be used. In view of the prevalance in specifications for concrete of strengths required at twenty-eight days it might be thought that tests at twenty-eight days should be included in B.S. No. 12. However, this would require the contractor to store consignments of cement for at least twenty-eight days before the results of the test were known, and there is in any case a general relationship between strengths at seven days and twenty-eight days.

An optional tensile test at 24 hours is retained for rapid-hardening Portland cement; this is no doubt for the benefit of makers of precast concrete products subject to British Standards that specify a bending test; the requirement is 300 lb. per square inch. It is possible that this test will be omitted from future standards if an alternative test at 24 hours can be produced.

In the case of compressive tests on 1 : 3 mortar cubes made with ordinary Portland cement the strengths required are increased from 1600 lb. per square inch to 2200 lb. per square inch at three days and from 2500 lb. per square inch to 3400 lb. per square inch at seven days. In the case of rapid-hardening Portland cement the strength required is now 3000 lb. per square inch at three days, and an additional test at seven days is included when the strength must not be less than 4000 lb. per square inch. These requirements are derived from a statistical analysis of test results during the last few years; the average quality of cement supplied in Great Britain is, of course, well above that required by this Standard, which stipulates guaranteed minima only.

Apart from the changes in strength tests perhaps the most important modifications are those relating to sampling and delivery. The sampling procedure in previous editions of B.S. No. 12 ensured a fair average sample of any consignment, however large it might be, so that it was theoretically possible for a mixture of very good and very bad cement to comply with the Standard.

Clause 10 of the new Standard is as follows: " Selection of Samples.—Each sample for testing shall weigh at least 15 lb. (6·80 kg.) and shall be truly representative of the consignment, or part of a consignment, sampled. The sample shall consist of a mixture of at least 12 equal sub-samples taken from places evenly spaced throughout the consignment, or part of a consignment, sampled. Sub-samples of bulk cement shall be taken from the bulk container, or containers,

during filling or emptying. For cement in bags, drums or other packages, not more than one sub-sample shall be taken from any one bag, drum or other package. Where there are fewer than 12 bags, drums or other packages to be sampled, one sub-sample shall be taken from each." We understand that this may be interpreted as follows. A customer who has ordered 1000 tons of cement may subdivide this into as many " parts of a consignment " as he wishes; for example, 2 parts of 500 tons each, 500 parts of 2 tons each, 20,000 parts of 1 cwt. each, or into any number of unequal " parts ". According to the last sentence of Clause 10, a " part " may constitute fewer than twelve bags, and therefore possibly only one bag. In this extreme case the " sub-sample " would become the " sample " and must therefore weigh at least 15 lb. and be truly representative of the " part of the consignment ", that is of one bag.

The modified delivery clause requires the number of bags to the ton or the approximate weight of cement to be legibly marked on each bag. This change from the long-established " 112 lb. net " is necessitated by new legislation in Great Britain relating to weights and measures. It is inevitable that the weight of the contents of bags of cement will vary with any packing plant in use, and the legal interpretation of " 112 lb. net " is so rigid as to make this marking impracticable.

Other changes in B.S. 12 include the omission of the sieve test for fineness, the simplification of the procedure for determining setting times and soundness, and adjustments of the permitted content of sulphuric anhydride and insoluble residue. It has been known for some years that the meshes of sieves complying with B.S. No. 410 can differ sufficiently to produce different residues with the same cement. Furthermore, the sieve test concentrates attention on the small coarser proportion of cement which has the least influence on its important properties. For these reasons the specific surface test is much to be preferred.

In the new B.S. for Portland-blastfurnace cement the compressive strength of mortar cubes remains at 1600 lb. per square inch at three days, but has been increased from 2500 lb. to 3000 lb. per square inch at seven days; a new (optional) test at 28 days calls for a strength of at least 5000 lb. per square inch. The compressive strength of concrete cubes (made as described in B.S. No. 12) must be at least 800 lb. per square inch at three days and 1600 lb. per square inch at seven days; there is also an optional test at twenty-eight days when the strength must be at least 3200 lb. per square inch.

In the case of low-heat Portland cement the compressive strengths of mortar cubes are increased to 1100 lb. per square inch at three days, 2000 lb. at seven days, and 4000 lb. at twenty-eight days. The requirements for the compressive strength of concrete cubes are 500 lb. per square inch at three days, 1000 lb. at seven days, and 2000 lb. at twenty-eight days. The heats of hydration are reduced to not more than 60 calories per gramme at seven days and 70 calories per gramme at twenty-eight days. The allowable contents of sulphuric anhydride, sulphide, sulphur, and magnesia have been increased.

It is understood that the international standards organisation is now drafting an international terminology for cements and tentatively accepting a strength test; it may be that this will lead to the production of a standard that will be acceptable to the cement-producing countries, and will be adopted throughout the world.

Method of Studying the Constitution of Cement.

The following is taken from the annual report of the Building Research Station (" Building Research 1956." H.M. Stationery Office. Price 5*s*. 6*d*.).

The behaviour of materials processed at high temperatures, among these being cements and slags, depends on the chemical constitution and proportions of the compounds present, and these are dependent on the composition of the raw material and on the heat treatment to which it has been subjected. Consequently, much attention has been given at the Station and elsewhere to studies of the constitution of the principal chemical compounds produced from the original raw materials, and to the sequence of their formation over various ranges of temperature and composition. Hitherto, it has been necessary to obtain this information by tedious indirect methods such as quenching or differential thermal analysis. A direct method, referred to in the previous Report (p. 15), uses a high-temperature microscope which gives results very much more quickly and with comparable accuracy. The material to be examined is held under a microscope at the tip of a thermocouple. The thermocouple, heated electrically to fuse the sample, also serves to indicate the temperature at which any observed change occurs in the melt. The different compounds present in the semi-molten material can be identified and their melting range determined by direct observation. While the basic idea of direct observation at high temperatures is not new, a novel method is used for heating the sample and measuring its temperature, and the simple design of the instrument affords a degree of flexibility and accuracy not previously attained.

During the year further developments have permitted observations to be made of samples exposed to special atmospheres. By this means it has been found possible to observe the behaviour of materials that are opaque in normal atmospheres, as, for example, some blastfurnace and steel-making slags and coal-ash slags which may contain considerable proportions of iron oxide. Other developments have extended the range of observations to beyond 2000 deg. C., though the precision with which the temperature of the sample can be estimated is somewhat less than for the normal range of the instrument up to 1800 deg. C.

These developments have made it possible to investigate materials that are too refractory for the application of usual methods. Several such studies, with practical applications to cement and ceramic technology, are in progress.

Extension of the range to temperatures above 2000 deg. C. has enabled a Research Fellow, appointed by Uganda Cement Industries, Ltd., to investigate the melting relations in the system $2CaO.SiO_2$—$3CaO.P_2O_5$, which are of importance because of the adverse effect P_2O_5 has on the quality of cement.

Uttar Pradesh Cement Works, India.*

By H. SWIFT, M.I.Mech.E., M.Inst.B.E.

OF HENRY POOLEY, CONSULTING ENGINEERS AND GENERAL MANAGERS OF THE WORKS

Grinding Cement.

The clinker is ground in a closed circuit. The clinker and gypsum are fed into a short ball-mill and the product elevated into a whirlwind-type separator; here the coarse particles are separated and conveyed back to the inlet end of the mill for further grinding, and the fine particles (or finished product) are conveyed to silos. Each mill is capable of producing 22 tons of cement per hour when grinding to a fineness of 5 per cent. retained on a 170-mesh sieve.

The clinker and gypsum are taken from the stores building by the grab-crane and discharged into reinforced concrete bunkers over the feed-tables of the mills. These bunkers are divided into two compartments; the compartment for clinker measures 19 ft. by 18 ft. at the top and has a capacity of about 160 tons, while the compartment for gypsum measures 18 ft. by 11 ft. at the top and has a capacity of about 85 tons. The lower part of each bunker is hoppered, and has a square opening with a valve and telescopic sleeve for regulating the amount of material delivered to the feed-tables. One 72-in. diameter table feeder for clinker and one of 48-in. diameter for gypsum regulate the proportions of material to the mills. These tables are similar to the feeders for raw materials. The 72-in. table is driven through a worm reduction-gear by a 5-h.p., 720 r.p.m. motor and the 48-in. table by a variable ratchet-gear from the driving-shaft of the 72-in. table. (See Fig. 10).

The clinker and gypsum are discharged from the feed-tables into a common chute where the rate of delivery to the mill is weighed. The chute ends in a drum-feeder which conveys the material into the internal helix of the mill-head.

Two mills, 9 ft. diameter by 24 ft. long, are installed, and each is divided into two compartments and lined with grinding plates and division plates of similar design to those in the raw mills. The first compartment is charged with 17 tons of high-carbon steel balls of 4 in. to 2½ in. diameter, and the second compartment with 48 tons of high-carbon steel balls of 2 in. to 1 in. diameter. The mills are driven by a cast-steel girth-gear, attached to the outlet head of the mill, by a countershaft which is coupled by a Bibby-type coupling to a single reduction gear, which reduces the speed of the 875-h.p. synchronous induction motor from 750 to 108 r.p.m.

The ground cement is discharged from the mill into a bifurcated chute for delivery either directly to a Fuller Kinyon pump for transport to silos when the mill is operating on the open-circuit system, or to an elevator for separation when the mill is operating on the closed-circuit system. The elevator has buckets 30 in. wide, is 69 ft. long, and is arranged for central discharge; it is driven by a 20-h.p., 720 r.p.m. motor. The cement is discharged from the elevator into a Sturtevant

*Concluded from JANUARY and MARCH 1958.

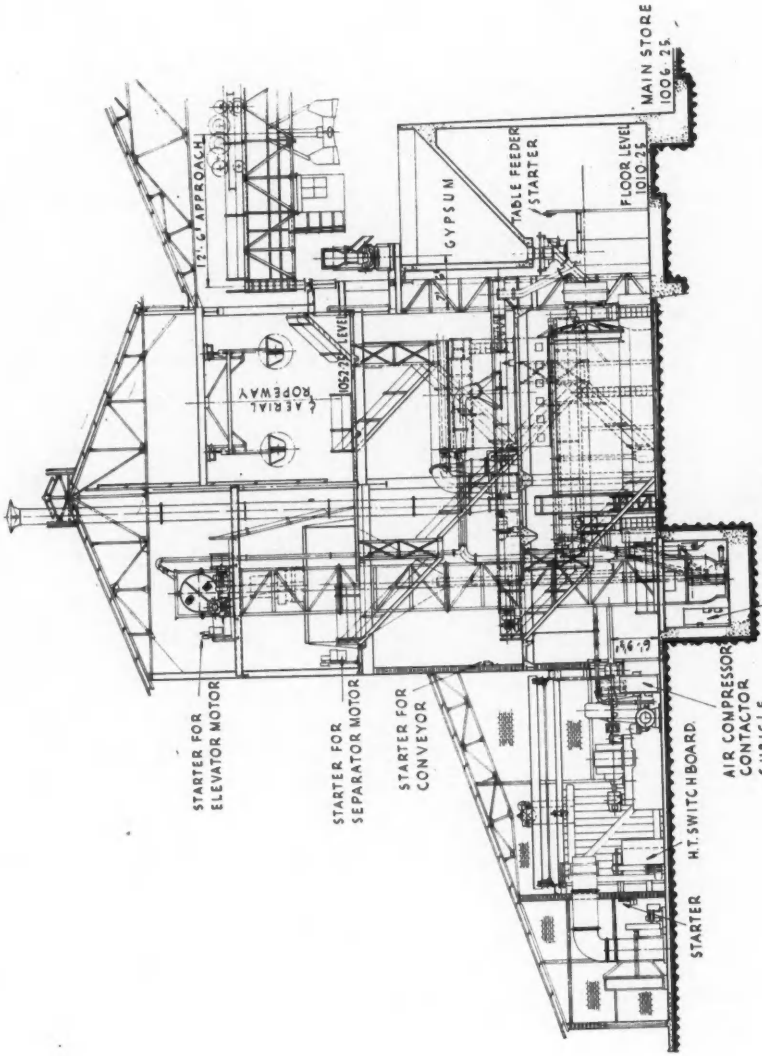


Fig. 10.—Section through Mill House.

Whirlwind air-separator of 16-ft. diameter, driven by vee-ropes from a vertically-mounted 75-h.p., 720 r.p.m. motor. The oversize material is discharged through a flanged outlet in the side of the lower cone and returned to the mill for further grinding by a totally-enclosed screw-conveyor 20 in. in diameter and 45 ft. long, driven through worm reduction-gear coupled directly to the central shaft by a 10-h.p., 720 r.p.m. motor. The finished cement is discharged from the centre of the lower cone of the separator through a flanged outlet and piped to the feed-hopper of a Fuller Kinyon pump of 6 in. diameter which transports it through 5-in. diameter steel pipes and discharges it through hand-operated two-way valves into the silos. The pumps are driven by 55-h.p., 960 r.p.m. motors directly connected to the helical shafts. Air for transporting the cement is provided by water-jacketed rotary air-compressors delivering 540 cu. ft. of air per minute at 30 lb. per square inch; the compressors have automatic mechanical lubrication and are driven through flexible couplings by 70-h.p., 960 r.p.m. motors.

DUST COLLECTION.—The mills are vented at the outlet end, and the dust is collected in a Visco bag-filter having six compartments each containing fourteen filter bags 8 in. in diameter and 8 ft. 8 in. long. A 15-h.p., 1460 r.p.m. motor is directly coupled to the main suction-fan, and a 2-h.p., 1440 r.p.m. motor is connected to the scavenging air-fan. Heating elements are fixed in a chamber on the discharge side of the scavenging air-fan and are thermostatically controlled from a regulator fixed in the inlet trunking to the filter chamber; the heated air raises the temperature of the moisture-laden air drawn through the mill and prevents condensation of water on the filter-bags. The filter-bags are automatically shaken by a sequence-timing mechanism operated by a 1½-h.p., 1440 r.p.m. motor. The dust collected in the lower hoppered part of the filter-bag chamber is discharged into a worm-conveyor and transferred to the feed-hopper of the Fuller Kinyon pump; this conveyor is driven at 30 r.p.m. by a back-geared motor of 1½ h.p. The grinding mills for raw materials and cement are in a lean-to 137 ft. long and 50 ft. wide built on to the stores building. The building over the cement mill is 63 ft. high to the eaves and has two floors; the lower floor contains the lower part of the separators, the rejects-return screw-conveyors, and the dust-filtration plant; the upper floor, which also forms part of the building carrying the ropeway-discharge and bucket-haulage system, contains the upper part of the separators and the heads of the elevators feeding the separators. An extension of the mill-house, 137 ft. long by 32 ft. wide, has a gantry carrying a 5-tons hand-propelled crane and contains the motors and reduction-gear driving the mills, the air-compressors for the Fuller Kinyon pumps, and high-tension and low-tension distribution boards. In a separate enclosure is a filtration plant for supplying clean air to the mill-motor house and the substation; the fan of the filtration plant is driven by a 25-h.p., 960 r.p.m. motor. In a basement are the three slurry pumps and the two Fuller Kinyon pumps. The mill building is a steel-frame structure with asbestos-cement sheet covering; the motor-house and substation are in a totally-enclosed steel-framed brick-panelled structure.

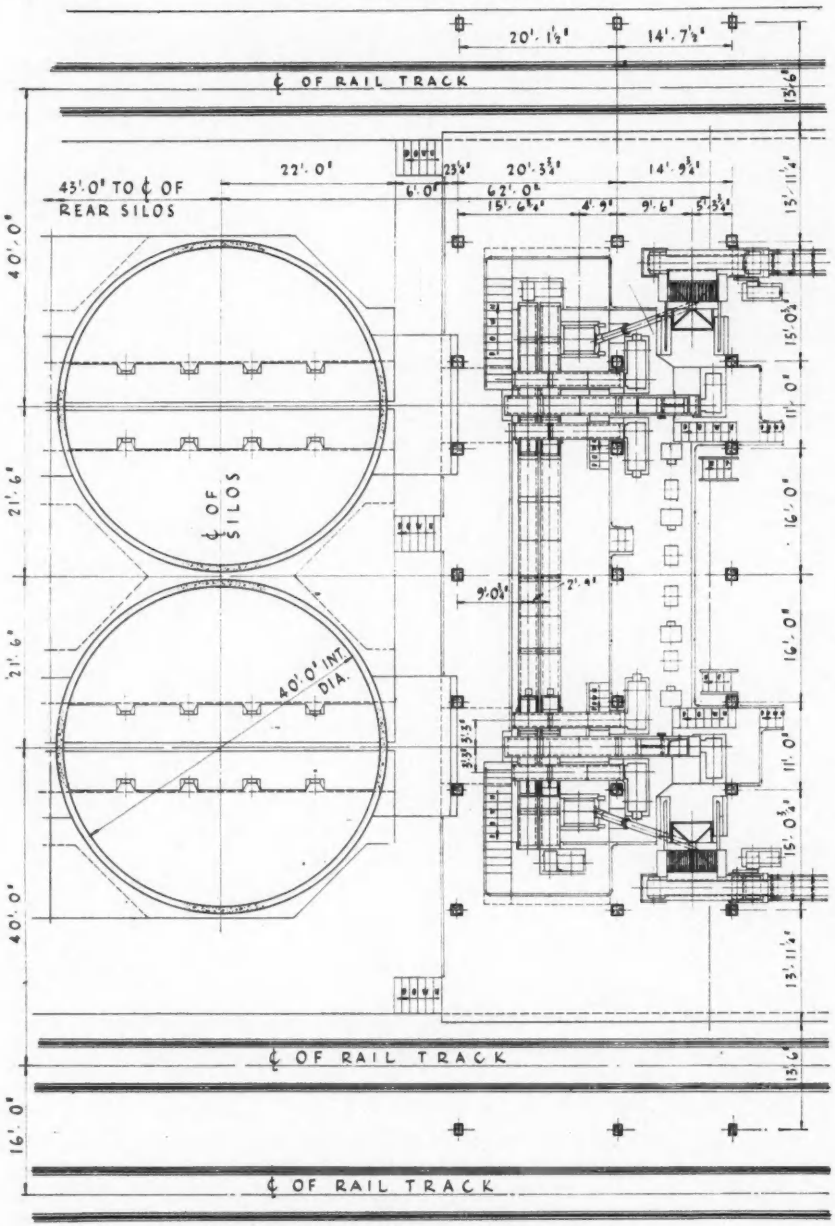


Fig. 11.—Plan of Silos and Packing Plant.

Cement Storage and Packing.

Two 5-in. pipelines from the Fuller Kinyon pumps carry cement pneumatically from the mills to the top of the silos, where it is distributed through two-way hand-operated valves into four reinforced concrete silos each of 40 ft. diameter and 60 ft. high and having a capacity of 2,400 tons. The air which carries the cement is discharged from the silos through a Visco bag-filter collector with four compartments, each compartment containing twelve filter bags of 6¼ in. diameter and 7 ft. long. The cement recovered is collected in the lower part of the filter and is discharged through a rotary valve back into the silos. A high-level indicator is fitted to each silo and connected with a control board, with audible and visual signals. (See *Figs.* 11 and 12).

The silos are in two rows of two and there is a continuous tunnel in the shape of an inverted V between each pair and containing the extraction gear. There are four outlets from each silo on each side of the tunnel through which cement is discharged, through semi-rotary valves, into extraction screw-conveyors 18 in. in diameter and 110 ft. 6 in. long in a trough formed in the base of the silos. The top of the screw is covered with an open-grid floor. The four conveyors under the silos discharge through valves and chutes into two transverse screw-conveyors which deliver cement to the packing department; these conveyors are of 24 in. diameter and 68 ft. 6 in. long; they are in a totally-enclosed steel casing, and are direct-driven through couplings by worm reduction-gear coupled to 15-h.p., 725 r.p.m. motors. The conveyors extracting cement from under the silos are connected in a similar manner to 25-h.p., 720 r.p.m. motors. PACKING.—In the packing department are two bag-filling machines, supplied with cement from the transverse conveyors which discharge cement into either of two elevators 69 ft. long with buckets 24 in. wide. These elevators take the cement to the fourth floor of the packing building and are driven at the top through worm reduction-gears by 15-h.p., 720 r.p.m. motors. From each elevator cement is discharged through a steel chute on to a vibrating screen where foreign matter is removed and discharged through a chute into a receptacle on the ground floor; the screen is totally-enclosed and is driven by vee-belts from a 5-h.p., 960 r.p.m. motor.

The screen delivers cement through a steel chute into a steel hopper, flanged at the outlet for connection to a four-spout packing-machine which fills valve gunny sacks with 112 lb. of cement at the rate of 60 tons per hour. Should bag-filling be interrupted and the hopper become full, the cement overflows through a chute into an overflow bunker of 60 tons capacity connected at the outlet with an extracting screw-conveyor 24 in. in diameter and 24 ft. long which delivers into the elevator feeding the screen, thus forming a closed circuit.

The packing machines are driven by 15-h.p., 960 r.p.m. motors, and the extracting screws by 10-h.p., 720 r.p.m. motors. The full bags fall from the packing machines on to belt-conveyors 24 in. wide and 14 ft. long, which in turn discharge on to belt conveyors 24 in. wide by 39 ft. long which deliver over the end for loading directly into railway trucks or motor lorries. Near

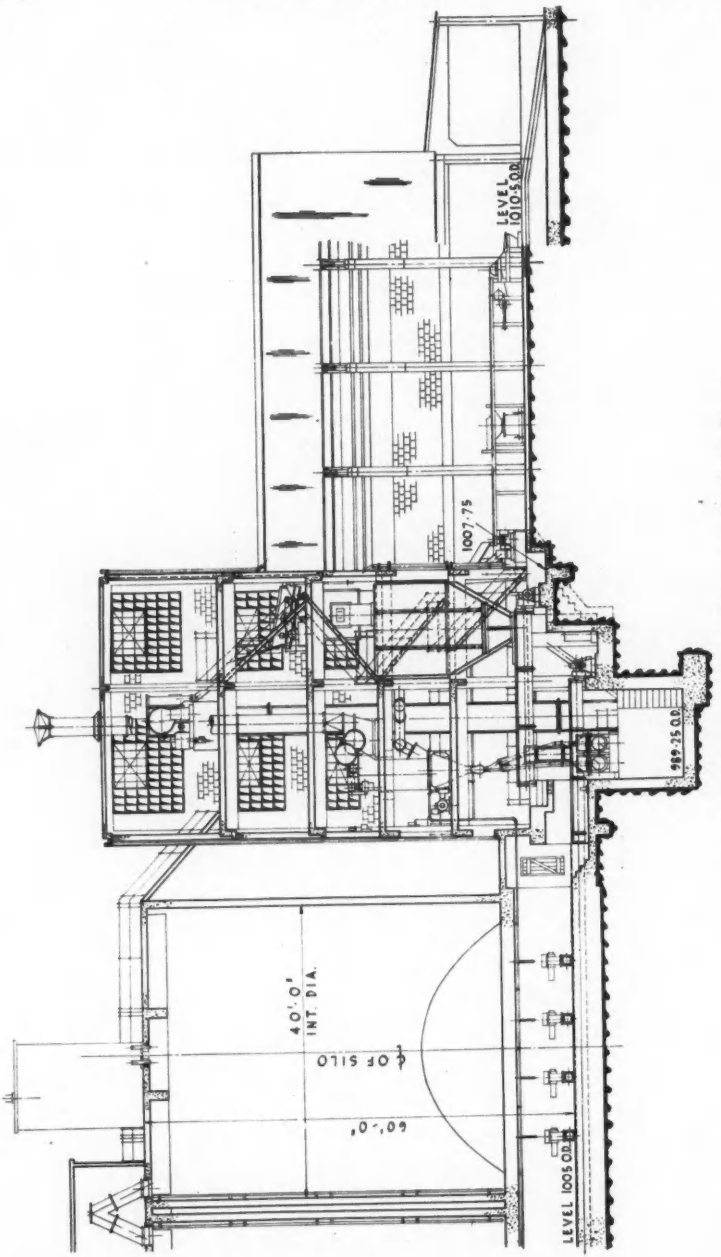


Fig. 12.—Section through Silos and Packing Plant.

the centre of the conveyors is a plough for transferring full sacks on to retractable belt-conveyors 24 in. wide by 23 ft. long, which can be propelled on to a railway truck; the retractable conveyors are fitted with two geared motors of 1½-h.p., one for driving the belt and the other for propelling the conveyor. The two conveyors from each packing machine are connected with a chain drive, and driven through a worm reduction-gear by a 10-h.p., 720 r.p.m. motor. A Visco-Beth dust-collecting machine is connected to the packing machines, and is similar in construction to the dust-collector in the mill house; it has seven compartments each containing fourteen bags of 8 in. diameter and 8 ft. 8 in. long, which are automatically shaken by a 1½-h.p. motor. The dust deposited in the lower part of the filter casing is collected by a screw-conveyor and discharged through a rotary-valve on to either of the transverse conveyors receiving cement from the silos; the collecting-screw and rotary-valve are driven at 30 r.p.m. by a 1½-h.p. geared motor, and the collecting fan is driven by a 22½-h.p., 1440 r.p.m. motor.

LOADING LOOSE CEMENT.—Cement for the Rihand dam will be transported loose to the site, a distance of about fifty miles, in containers of 10 tons capacity. For this purpose cement from one of the packing hoppers, instead of overflowing into the overflow bunker, discharges into a totally-enclosed screw-conveyor 20 in. diameter by 20 ft. long, driven through worm reduction-gear by a 7½-h.p., 720 r.p.m. motor. This conveyor discharges into a hopper of about 10 tons capacity, with two flanged outlets and valves, situated over two Simon constant-weight feeders each of which transfers and weighs cement from the hopper to two 6-in. Fuller Kinyon pumps at the rate of 30 tons per hour. The pumps are driven by 55-h.p., 960 r.p.m. motors. Two rotary air-compressors, each of 540 cu. ft. capacity, at 30 lb. pressure, and direct-coupled to 70-h.p., 960 r.p.m. motors, supply air for transporting the cement through pipes of 5 in. diameter discharging into two steel silos through power-operated two-way valves. The silos have a capacity of 500 tons each, and have an outlet for connection to the loose-cement vehicles.

The packing equipment is in a four-story reinforced concrete structure 38 ft. long by 86 ft. wide and 59 ft. high, with an extension 58 ft. long, 86 ft. wide, and 37 ft. high with canopies along each side and at one end over the rail and road loading platforms.

Power House.

The power plant includes three boilers and three steam turbines with a total capacity of 7,200 kW. which provide power for the factory and for the houses of the employees; two boilers and two steam turbines are sufficient to meet the demands of the factory. The total connected motor-load at the factory and quarry is 8,939 h.p., including two motors of 875 h.p. and two of 775 h.p. at 3,300 volts and 169 motors up to 360 h.p. at 440 volts.

The boilers are of the four-drum water-tube type with a heating surface of 4,900 sq. ft. They operate at a working pressure of 325 lb. per square inch at the outlet of the superheater, with a final steam temperature of 725 deg. F.

Each boiler will economically evaporate 25,000 lb. of steam per hour when supplied with water at a temperature of 120 deg. F. The boilers are fired by forced-draught chain-grate mechanical stokers, 16 ft. long by 10 ft. wide, with an effective grate area of 160 sq. ft. The forced-draught fans are driven by 25-h.p., 725 r.p.m. motors and the induced-draught fans are driven by 39-h.p., 725 r.p.m. motors. Economisers of the grilled-tube type are fitted, with sixty tubes 12 ft. long having a heating surface of 419 sq. ft.

A steam-driven direct-acting pump with a capacity of 60,000 lb. of water per hour, and two electrically-driven pumps each with a capacity of 34,500 lb. per hour, supply to the boilers; the electrical pumps are driven by 38-h.p., 2,900 r.p.m. motors. The water is treated in a Kinnicott base-exchange water-softener and a mechanical quartz-filter with a capacity of 2000 gall. per hour. Ash discharged from the boilers falls into steel chutes the ends of which are below the water level of an ash conveyor, 36 in. wide by 111 ft. 6 in. long; the first 70 ft. is horizontal and is beneath the three boilers, while the other 41 ft. 6 in. is inclined and discharges into a quenching-pit in the store building from whence the ashes are grabbed and discharged into store or to railway wagons for disposal. The conveyor is driven by a 5-h.p., 720 r.p.m., motor. In case of a breakdown of the conveyor, the chutes from the boilers are fitted with by-pass valves to discharge into U-shape tipping trucks of 20 cu. ft. capacity; these trucks travel on a 24-in. rail track in the basement of the boiler room, are raised by a 1-ton electric hoist-block to ground level, and the ash is taken to tip.

GENERATING PLANT.—The generating plant comprises three Ljungstrom turbo-alternators (*Fig.* 13) each having a continuous maximum rating of 240 kW. at 3000 r.p.m. when supplied with steam at a pressure of 300 lb. per square inch and

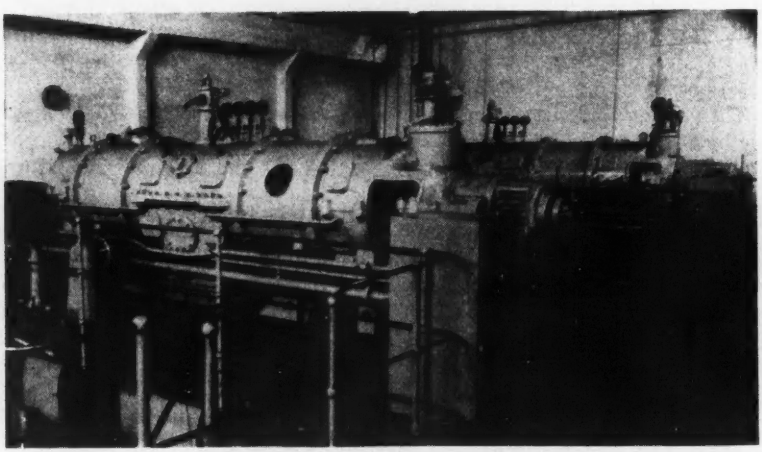


Fig. 13.—The Turbo-Alternators.

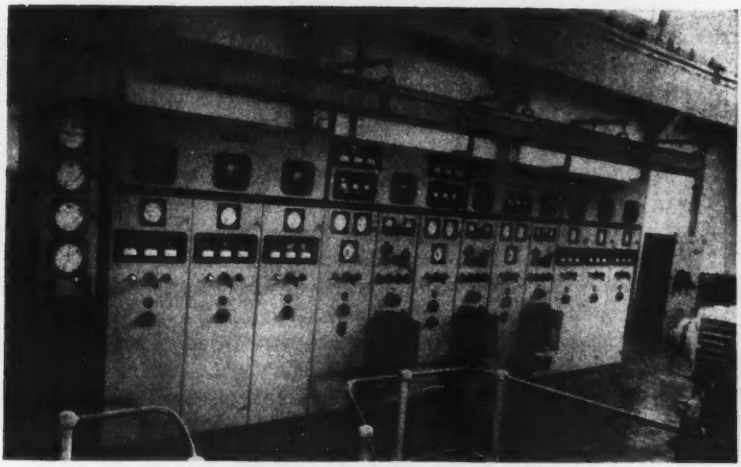


Fig. 14.—The Alternator Switchboard.

at 700 deg. F. The alternators generate at 3300 volts, 50 cycles, at 0·9 power factor; the condensers have a rating of 22,000 lb. per hour with a cooling surface of 3000 sq. ft. The circulating water pumps are driven by 80-h.p., 960 r.p.m. motors and have a capacity of 4100 gallons per minute at 48 ft. total head; they discharge into a spray-cooling pond in three parts, each 220 ft. long by 52 ft. wide by an average depth of 5 ft., and having a total capacity of 1,000,000 gallons.

The current from the alternators is passed to a 12-panel board (*Fig.* 14) with spring-operating units of 100-M.V.A. breaking capacity which control the supply to the main switchboard for distribution in the factory and to power station auxiliaries; the latter are supplied from three 300-kVA., 3300—440 volts step-down transformers which deliver to a seven-panel low-tension switchboard supplying power direct to the larger motors and to fuse-boards for the smaller motors.

The steam-raising and generating equipment are in a reinforced concrete structure with walls of concrete blocks. The boilers occupy an area 78 ft. 8 in. long by 68 ft. 8 in. wide by 35 ft. 9 in. high to eaves, with an annexe 42 ft. long by 19 ft. 4in. wide by 32 ft. high accommodating the water-treatment plant and boiler-feed pumps. The part occupied by the turbo-alternators is 78 ft. 8 in. long by 48 ft. wide by 35 ft. 9 in. high, with a crane gantry 27 ft. 6 in. above floor level carrying a hand-propelled crane of 10 tons capacity. The roof is covered with asbestos cement sheeting.

Electrical Distribution.

The main outgoing 3000-v. feeders from the power station are connected to a 12-panel switchboard in the mill-motor room; four panels control the supply to the raw-mill and cement-mill motors; three panels control the supply to three 1250-kVA., 3300—440 volt step-down transformers for small motors and general

use; and one panel controls the supply to a 750-kVA., 3300 v.—11,000 v. step-up transformer for power transmission to the quarry. Power from the three 1250-kVA transformers is connected to a 14-panel, 440-v. switchboard from which cables extend to switchboards in the various buildings for supplying direct to motors of 30-h.p. and over and to fuse-distribution boards for motors below 30 h.p.

From the 750-kVA. transformer an 11-kV. cable about three miles long supplies power to the quarry and housing estate. At the quarry a 750-kVA. transformer steps down the incoming 11,000 volts to 440 volts and supplies through an oil circuit-breaker to a 4-panel distribution board from which power is taken to the crushing and quarry equipment. From the sub-station an 11,000-v. supply is taken on overhead lines to the quarry face, where two 200-kVA., 11,000—440-v., pole transformers step down the voltage for the shovels.

The main lighting switchboard is in the mill-motor house and consists of three oil circuit-breakers and twelve fuse-switch units, and is supplied from the 14-panel low-tension switchboard by duplicate cables; from here cables supply all parts of the factory; the lighting circuits are wired with V.I.R. aluminium-sheathed cable.

WORKSHOP.—The workshop building is a reinforced concrete frame structure with concrete-block walls. It is 118 ft. long by 32 ft. wide and 21 ft. high to the eaves, with a lean-to building 18 ft. wide and 11 ft. 6 in. high extending the full length on both sides. An overhead hand-propelled crane of 3 tons capacity is installed.

WATER.—Water is pumped a distance of about 1¾ miles from the Ghagar river, by two centrifugal pumps, each with a capacity of 30,000 gallons per hour. The pumps deliver into a 12-in. cast-iron main which discharges at the factory into a filtration plant and thence to an elevated reinforced concrete storage tank 38 ft. in diameter, 50 ft. high, and of 60,000 gallons capacity, from which it is distributed as required.

HOUSING.—Houses built of concrete blocks have been built for the employees at the factory and at the quarries, and there are also gardens, a hospital, schools, a club room, and recreation grounds.

Acknowledgment is made to the Industries " B " Department of the Uttar Pradesh Government and to Mr. T. L. Mahendra, the director of the cement works, for permission to publish the foregoing description.

Proposed Cement Works in Costa Rica.

The government of Costa Rica has called for tenders for the construction of a cement factory capable of producing 75,000 metric tons in the first year and 112,500 metric tons in the second year of operation.

Cement Production in Mexico.

The quantity of cement produced in Mexico during 1957 is stated to have exceeded by 13 per cent. the quantity made in 1956.

The Influence of the Method of Burning on the Structure of Lime.

TESTS ON CRYSTALLINE CALCIUM CARBONATE.

A LABORATORY study of the oxide formed by burning pure Iceland spar under various conditions of temperature and pressure is described by Mr. R. Hedin in a recent number of "Zement-Kalk-Gips." The following is a summary of the article.

A small resistance-furnace lined with platinum and enclosed in an autoclave was used for the tests, and the temperature was measured by a platinum and platinum-rhodium thermocouple. In all cases burning took place in an atmosphere of carbon dioxide at a measured pressure, and normally lasted for two hours. The starting material consisted of individual crystals of Iceland spar (1 mm. to 2 mm. in size) of very high purity. The linear contraction of the material was found from measurements of the specific gravity of the oxide made with a micro-pycnometer.

The method used for burning the material was as follows. The pressure in the autoclave was raised above the dissociation pressure corresponding to the required temperature. When the required temperature had become steady, the pressure of the carbon dioxide was lowered to that required for the test. At the end of the process of burning, the temperature was reduced and the pressure regulated so that the dissociation equilibrium was maintained throughout the period of cooling until a temperature of 600 deg. C. was reached. The oxide was weighed to determine the degree of dissociation, and the contraction was measured.

Values of contraction were obtained for temperatures from 700 to 1200 deg. C., and of pressure from 2 mm. Hg. to 25 atmospheres. The results show that, if the pressure is increased while temperature remains constant, the contraction first increases, then becomes constant, and finally falls. The small contraction at low pressure may be due to local cooling of the specimen caused by the high rate of dissociation due to the low pressure. The reduction of contraction at higher pressures indicates that the contraction depends on the rate of dissociation as well as on temperature. The values of pressure at which this reduction occurs are almost the same as those at which dissociation begins to be retarded by rise in pressure.

For each temperature there is a maximum value of the contraction which occurs at medium pressures. From a low value at 710 deg. C. this increases up to 1020 deg. C., then falls at 1120 deg. C. and rises again at 1210 deg. C. at which temperature it is very near the theoretical maximum of 23·6 per cent. At all temperatures below 1090 deg. C., complete dissociation occurs within two hours. Above this temperature a pronounced decrease in dissociation occurs, but as the temperature increases the rate of dissociation rises again rapidly.

These results are explained as follows. The dissociation zone moves inwards with a definite velocity from the surface towards the centre of the crystal. Below 1090 deg. C. this velocity increases with temperature if the dissociation occurs

under constant pressure. The volume of the pores of the resulting oxide decreases as the rate of dissociation increases. Below 1000 deg. C. the volume of the pores is large enough to cause no appreciable resistance to the gas released, but at higher temperatures the smaller volume of the pores causes greater resistance, and therefore a rise in pressure in the reaction zone. Since the rate of dissociation depends on the difference between the pressure in the reaction zone and the equilibrium pressure at the temperature concerned, the dissociation inside the crystals is retarded and the contraction is reduced. The resistance caused by the outer layers of oxide becomes progressively greater as the temperature increases, but the equilibrium pressure increases much faster. Thus the rate of dissociation inside the crystal again becomes greater, and the contraction will therefore increase until, at 1210 deg. C., it approaches the theoretical maximum for compact oxide.

Electron-microscope studies (using negative impressions) show that at 910 deg. C. the surface of the oxide is fine-grained with many pores which are uniformly distributed. At 1020 deg. C., the grain size is very much larger, but the porosity is still large and uniform. At 1120 deg. C. partial sintering is seen and, instead of uniform porosity, there are larger crater-like cavities which occur at random in the surface. At 1210 deg. C. a compact sintered mass is formed with rifts through which gas has presumably escaped.

Further experiments were made with crystals coated with a thin layer of compact oxide by heating for a short time at 1210 deg. C. at a pressure slightly below equilibrium pressure. When burnt at 1120 deg. C. these crystals had a much smaller contraction than crystals burnt without preliminary heating. Crystals which had been preheated at 1210 deg. C. at a pressure above the equilibrium pressure, and had no oxide layer, had normal contraction. These experiments confirm that a compact external layer of oxide reduces the total contraction of the crystal. Specimens which have completely dissociated at lower temperatures change only slightly in volume when subsequently heated at 1210 deg. C. for two hours.

Extension of Cement Works in Ceylon.

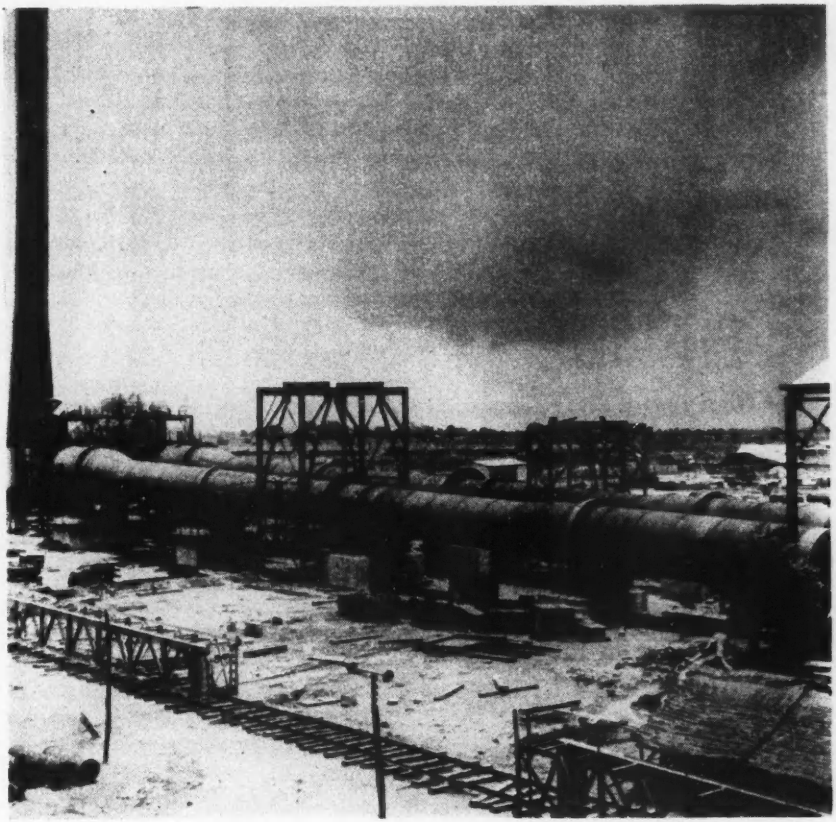
It is reported that the Government of Ceylon has decided to install another kiln at the Kankesanturai cement works. This will increase the capacity of the works from 75,000 tons to 200,000 tons a year.

New Cement Works for Pakistan.

The Government of Pakistan has decided to build two new cement factories. Further information may be had from the Export Department of the Board of Trade (reference C.R.E. 6157/56), Horse Guards Avenue, London, S.W.1.

Production of Cement in Spain.

In the year 1957 the production of cement in Spain amounted to 4,487,000 tons, an increase of 12 per cent. over the previous year.



UTTAR PRADESH CEMENT WORKS

Designed to produce 700 tons of Portland Cement a day, the Government Cement Factory at Churk was equipped with machinery by Vickers-Armstrongs. The kilns, mills, primary crusher and other major units were manufactured at Barrow and the project was completed in 1954.

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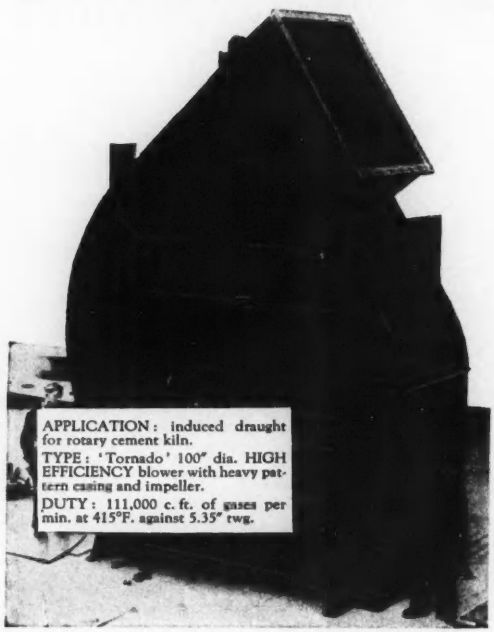

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New Cement Works in Canada.

The new works at Clarkson, Ontario, of the St. Lawrence Cement Company has recently been completed (*Fig.* 1). It has a capacity of 500,000 tons a year. Work on the site was started in September 1955, and the work required the removal of 600,000 cu. yd. of earth and the placing of 60,000 cu. yd. of concrete.

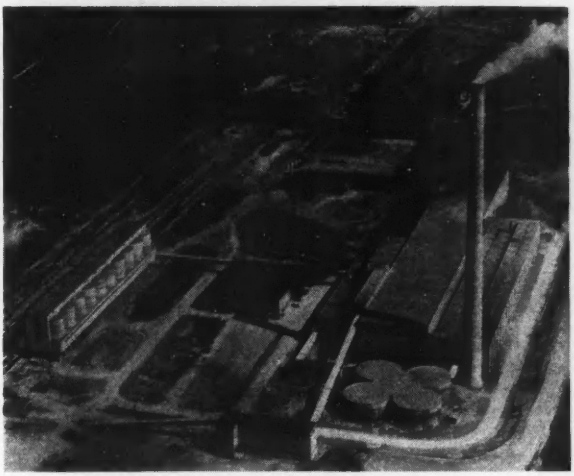

Fig. 1.—General View of Works.

The structures are of prestressed concrete. The chimney is 556 ft. high; it is of reinforced concrete.

The raw materials are shale (which is quarried near the works), and limestone, which is brought to the works by rail. There are two kilns 402 ft. long by 13 ft. 6in. diameter. The delivery of the slurry to the kilns is controlled by radio isotopes.

The U.S.A. Cement "Reference" Laboratory.

The Cement "Reference" Laboratory, which has since 1929 inspected the laboratories of cement producers and independent laboratories for the purpose of giving assistance in the testing of cements, operates from the U.S. National Bureau of Standards, and is supported jointly by this Bureau, the American Society for Testing Materials, the Bureau of Public Roads, and the U.S. Corps of Engineers. Its main purpose has been to bring about a steady degree of uniformity in methods of testing cement. The Laboratory has now agreed to undertake similar work in connection with the testing of concrete, in response to requests from the construction industry and particularly from those responsible for the new national system of highways.

Variations in the Strength of Cement.

The variation in the strength of Portland cement made in the U.S.A. is the subject of a bulletin written by Mr. Stanton Walker and issued by the U.S. National Ready Mixed Concrete Association, in which are described the results of tests made by the Association on samples of cement secured from five sources every two weeks during a year. These were compared with a " control " cement consisting of a mixture of five different brands of cement which was stored in sealed containers and used as a standard of comparison. The series comprised compressive tests on mortar cubes of all the cements, tests on concrete made with some of the samples, and tests on both mortar and concrete of selected samples.

The results are given in the form of graphs showing the variations from the average strength. Generally the strength of mortars made with the control cement varied by less than 5 per cent. above and below the average. In the case of the other cements, the strength of 1 : 3 cement-sand mortars made with the different brands varied from 20 per cent. above to 20 per cent. below in the case of cement No. 2; from 18 per cent. above to 18 per cent. below in the case of No. 3; from 22 per cent. above to 10 per cent. below in the case of No. 4; from 15 per cent. above to 33 per cent. below in the case of No. 5; and from 10 per cent. above to 16 per cent. below in the case of No. 6.

Test made on cubes of concrete made with the same cements showed variations in strength corresponding almost exactly to the variations in the strength of mortar made with the same cements.

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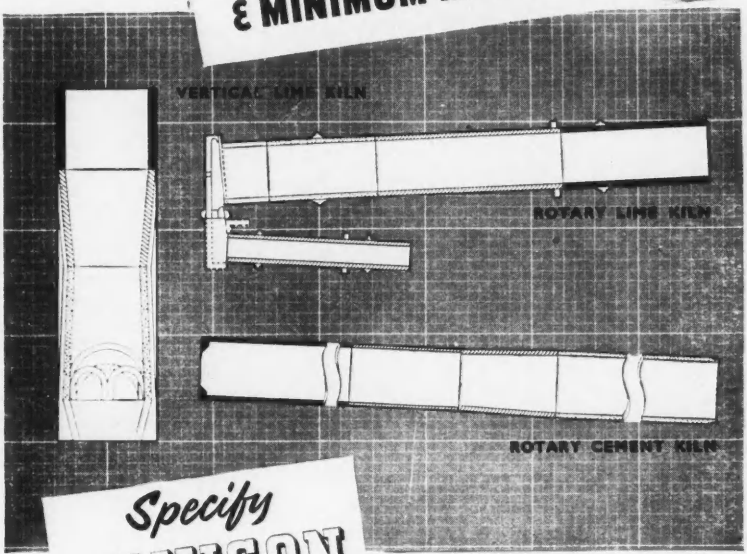

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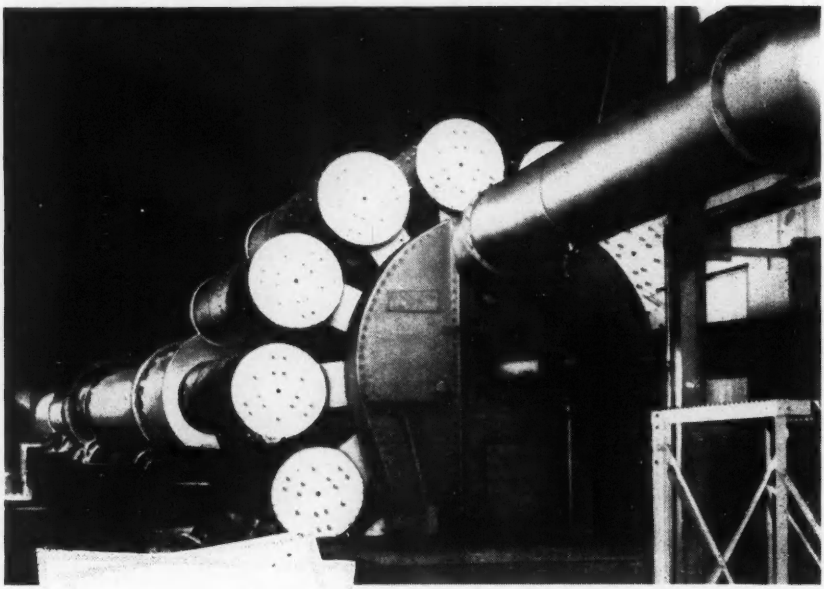

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